Name: _____

Class: _____

Due Date: _____

E.1 Structure of the Atom

Understandings

- The Geiger-Marsden-Rutherford experiment and the discovery of the nucleus.
- Nuclear notation ${}^{A}_{Z}X$ where A is the nucleon number, Z is the proton number, and X is the chemical symbol.
- Emission and absorption spectra provide evidence for discrete atomic energy levels.
- Photons are emitted and absorbed during atomic transitions.
- The frequency of the photon released during an atomic transition depends of the difference in energy level as given by $E = hf$.
- Emission and absorption spectra provide information on the chemical composition.

Equations

$E = hf$

Additional HL Understandings

- The relationship between the radius and nucleon number for a nucleus as given by $R = R_0 A^{1/3}$ and implications for nuclear densities.
- Deviations from Rutherford scattering at high energies.
- The distance of closest approach in head-on scattering experiments.
- The discrete energy levels in the Bohr model for hydrogen as given by $E = -\frac{13.6}{n^2}$ eV.
- The existence of quantized energy and orbits arise from the quantization of angular momentum in the Bohr model for hydrogen as given by $mvr = \frac{nh}{2\pi}$.

Additional HL Equations

$R = R_0 A^{1/3}$

$E = -\frac{13.6}{n^2}$ eV

$mvr = \frac{nh}{2\pi}$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Use your favorite sources to answer the following questions

1. C: Draw and describe the main points of the *Thomson model of the atom*:

2. C: Describe the Geiger-Marsden-Rutherford experiment. Draw an image if you have to.

3. C: True or false: Your brain is mostly empty space.

4. C: Describe and draw the *Rutherford model of the atom*:

5. C: Which year were the following particles discovered?

Electron	Photon	Atomic Nucleus
Neutrino	Proton	Neutron

6. C: Define *nucleon number A.*

7. C: Define *atomic number Z.*

8. C: Define *nucleon.*

9. C: Define *nuclide.*

10. C: Define *discrete* and *continuous.*

11. C: Circle the correct answers in italic font: Free electrons have *continuous/ discrete* energy. Bound electrons in an atom have *continuous/discrete* energy.

12. C: Define *ground state* and *excited state* of an electron in an atom. Draw a figure.

13.C: Define *transition.*

14.C: Which has more energy: an electron in an atom which is close to its nucleus or an electron in an atom which is farther from its nucleus? Draw a figure.

15.C: Define *absorption spectra*. What happens to an electron in an atom during *photon absorption*? Draw a figure.

16.C: Define *emission spectrum*. What happens to an electron in an atom during *photon emission*? Draw a figure.

17.C: We use the equation $E = hf$ for *electromagnetic waves*. Define and give the units of each variable.

Additional HL Content

18.C: Give the meaning of the equation $R = R_0 A^{1/3}$ and define each variable.

19.E: Determine the radius of a silver nucleus. Silver has an atomic mass of 108.

20.E: Determine the radius of a gold nucleus. Gold has an atomic mass of 197.

21.C: What is the meaning of *nuclear density*? What is the value of the *nuclear density*?

22. C: Use Newton's second law of motion, the equation for total energy, the equation for angular momentum $\vec{L} = r \times \vec{p}$, and the assumption that the angular momentum of an electron orbiting a hydrogen atom is quantized: $mvr = n\left(\frac{h}{2\pi}\right)$ to derive the equation for the energy of an electron orbiting a hydrogen atom is $E_{\text{electron}} \approx -\frac{13.6}{n^2}$ eV.

23. C: What is the meaning of the equation $E = \frac{-13.6}{n^2}$ eV?

24. E: Determine the radius of the three lowest energy levels of an electron in a hydrogen atom.

25. E: Complete the following table for the four lowest energy levels of an electron in a hydrogen atom.

Energy level	n	E(eV)	E(Joules)
Ground state			
First excited state			
Second excited state			
Third excited state			

26. E: Determine the gain in total energy in eV when an electron jumps from the first excited state ($n = 2$) to the fifth excited state ($n = 6$).

27. E: Determine the gain in total energy in eV when an electron jumps from the ground state ($n = 1$) to the third excited state ($n = 4$).

28. C: Describe the *Bohr model of the atom*.